IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF OHIO
EASTERN DIVISION

IN RE: OHIO EXECUTION PROTOCOL LITIGATION **This document relates to: PLAINTIFF HENNESS**	**Case No. 2:11-cv-1016** **CHIEF JUDGE EDMUND A. SARGUS, JR.** **Magistrate Judge Michael R. Merz**

Expert Report of Dr. Mark Edgar

I, Mark Edgar, under the penalty of perjury, declare the following to be true:

1. My name is Mark A. Edgar, M.D. I am an Associate Professor of Pathology at Emory University School of Medicine, in Atlanta, Georgia. I am a practicing, Board-certified anatomic pathologist and neuropathologist, and I am involved in resident training in anatomic pathology.

2. The factual statements I make in this declaration are true and correct to the best of my knowledge and experience.

3. I have been asked by counsel representing inmate Warren K. Henness to provide opinions related to the lethal injection execution protocol employed by the State of Ohio.

4. In preparing this report and reaching the expert opinions contained herein, I have reviewed, among other materials, autopsy reports of inmates executed using lethal injection protocols employing midazolam, including reports for: Thomas Arthur, Chadwick Banks, Oscar Bolin, Jr., Christopher Brooks, Juan Chavez, Jerry Correll, Eddie Davis, Michael Eggers, Ricky Gray, William Happ, Robert Hendrix, John Henry, Robert Henry, Paul Howell, Jack Jones, Jr., Darius Kimbrough, Johnny Kormondy, Ledell Lee, Clayton Lockett, Torrey McNabb, Robert Melson, Walter Moody, William Morva, Ronald Smith, Charles Warner, Kenneth Williams, Marcel Williams, and Joseph Wood. In addition, I performed an autopsy on Robert Van Hook, including conducting microscopic analysis of histological slides prepared from samples, and I wrote a formal report of my findings. I also reviewed eyewitness media accounts of Mr. Van Hook's execution, as well as eyewitness accounts of the execution of Billy Ray Irick in Tennessee. I also reviewed an Excel spreadsheet collecting eyewitness observations made during the executions of inmates listed above and others for which there was no formal autopsy report to review, and the accompanying citation list. I have reviewed the chancery court's decision in *Abu-Ali-Abur'Rahman et al vs Parker* [Tennessee Chancery Court, case No. 18-183-II(III)]. I also watched and heard the testimony of Dr. David Greenblatt, Dr. David Lubarsky, and Dr. Roswell Lee Evans in that trial. I have also reviewed the transcript of the entire trial. I read the 9/2/2018 declaration of Dr.

David A. Lubarsky concerning witness observations made during the execution of Billy Ray Irick. I reviewed the motion for preliminary injunction for Warren K. Henness filed in this case (Case No. 2:11-cv-1016). I read the district court decision dated January 26, 2017 in *In re Ohio Execution Protocol Litigation*, No. 2:11-cv-1016, 235 F. Supp. 3d 892 (S.D. Ohio Jan. 26, 2017). I also reviewed the Sixth Circuit opinion reversing that district court decision in *Fears v. Morgan*, 860 F.3d 881 (6th Cir. 2017) (en banc). I also reviewed the other following decisions in this case: *In re Ohio Execution Protocol Litigation (Otte)*, No. 2:11-cv-1016, 2017 U.S. Dist. LEXIS 145432 (S.D. Ohio Sept. 8, 2017); *In re Ohio Execution Protocol Litigation (Campbell & Tibbetts)*, No. 2:11-cv-1016, 2017 U.S. Dist. LEXIS 182406 (S.D. Ohio Nov. 3, 2017); and *Campbell v. Kasich*, 881 F.3 447 (6th Cir. 2018). I reviewed scientific articles related to an experimental model of pulmonary edema (*Journal of Clinical Investigation* 1965; 44(3): 458-464), and a study on medicolegal aspects of drowning (Mukherjee et al., Medicolegal study of drowning deaths. *Journal of Research in Forensic Medicine and Toxicology* 2016; 2(1):1-4). I reviewed an article on acute pulmonary edema (*NEJM* 2005; 353: 2788-2796). I reviewed a scientific paper regarding the value of cumulative evidence in medicine as it relates to meta-analyses by Nordmann et al., *Meta-analyses: what they can and cannot do*, Swiss Med. Wkly. 2012;142:w13518. I have reviewed the package insert for midazolam. I have read the prescribing information for pentobarbital injectable from

Leucadia Pharmaceuticals (Revised October 2017). I have read the Ohio lethal injection protocol effective October 7, 2016.

BACKGROUND AND EXPERT QUALIFICATIONS

5. My professional qualifications are fully expressed in my curriculum vitae appended to this report. Brief highlights include the following:

6. I am a currently practicing anatomic pathologist and neuropathologist and have been continuously practicing for the past 23 years.

7. I'm also an Associate Professor of pathology in the Department of Pathology at Emory School of Medicine in Atlanta, Georgia, where I am also the Director of Quality Assurance for anatomic pathology. I am also the Assistant Director of the Bone and Soft Tissue Pathology Expert Consultation Service, where I review diagnostically challenging cases submitted for expert review from across the country.

8. I have published more than 80 academic works, including book chapters and original articles.

9. I have provided expert witness testimony in one case in the last four years: *Abdur'Rahman v. Parker*, Chancery Court for State of Tennessee, Twentieth Judicial District, Davidson County, TN, Part III, Case No. 18-183-II (III). In that case, I served as an expert witness for the plaintiffs. I provided testimony at trial, and I was deposed as well.

10. I am being compensated at the rate of $400 per hour for research, evidence collection and review, document review, consultation, report-writing, testimony, travel, and any other work related to this case.

SCIENTIFIC BASES AND OPINIONS REGARDING OHIO'S THREE-DRUG LETHAL INJECTION PROTOCOL

I. Pulmonary Edema

11. Pulmonary edema is the movement of fluid from small blood vessels in the lung (alveolar capillaries) into the air spaces. (Ware LB and Matthay MA, Acute pulmonary edema, *New England Journal of Medicine*; 2005:353: 2788-2796). It can be caused by increased hydrostatic pressure and congestion in capillaries as the result of fluid back-up in the lungs resulting from a failing heart (cardiogenic pulmonary edema). It can also be the result of a variety of chemical, infectious, or physical insults to the lung, such as inhaled toxic gas or reaction to intravenous contrast media used by radiologists.

12. Pulmonary edema has a variety of effects on the body. First, the presence of fluid in airspaces (alveolar sacs) interferes with normal gas exchange, which reduces the amount of oxygen in the blood. It also increases the work of breathing; in mild cases, this causes shortness of breath, sometimes coughing or wheezing, and increase in the rate of breathing, but with increasing severity it greatly increases the work of breathing such that the chest muscles and diaphragm strain as they expend greater effort to move air into the lungs. This also produces sensations similar to drowning or asphyxiation as fluid occupies a greater volume of the air spaces. Severe pulmonary edema is an intolerable state that produces panic and terror.

13. Normal adult lungs weigh about 350-400 grams and these lung weights are seen in people who die very suddenly as from a ruptured aneurysm in the brain or a large blood vessel. Most deaths are not instantaneous, however, but are a more gradual process in which multiple organs gradually fail together, ultimately resulting in a failing heart. This results in heavy, congested lungs.

14. Significant degrees of pulmonary edema are evident to the naked eye. Lungs are typically heavy and wet, with cut sections leaking fluid and resembling a wet sponge as fluid pours from the tissue when it is squeezed. Blood is often present in the fluid, giving it a reddish color described as serosanguineous. Pulmonary edema may arise suddenly, over the course of minutes. When it is fulminant—that is, when it is both sudden (*i.e.*, acute) *and* severe in onset—it may result in the presence of foam or froth in the small/lower or large/upper airways (bronchi and trachea) resulting from the mixture of air, edema fluid, and pulmonary surfactant (a detergent-like secretion normally present in the airspaces). Minor degrees of pulmonary edema may result in heavy lungs that do not appear wet, but edema fluid may be evident in lung tissue examined under the microscope.

II. Ohio's Execution of Robert Van Hook

15. It is my understanding that Ohio recently executed Robert Van Hook, using a lethal injection protocol of 500 mg of midazolam, followed by

injection of rocuronium bromide, followed by injection of potassium chloride.

16. I conducted an autopsy of Mr. Van Hook's body the day after he was executed. This took place in the Montgomery County Coroner's Office in Dayton, Ohio, a busy, well-equipped facility in which forensic autopsies are conducted daily. Autopsy technicians assisted in removal of organs, collection of blood for toxicology studies, and photography.

17. An external examination of the body was conducted and photographs were taken by the Coroner's Office photographer. The autopsy was conducted in the usual manner, with a Y-shaped incision into the chest and abdomen and an oscillating saw used to remove the front portion of the chest cage. After that, an autopsy technician removed organs from the chest and abdominal cavities, weighed each, and placed them on a metal table for examination. I then sectioned each organ at 1 to 2 cm intervals, and examined cut surfaces for any evidence of gross pathology. As I did my examination, I described abnormalities to another technician who made a written note of the findings. I selected representative pieces of tissue from each organ examined and placed them in formalin (a preservative/fixative solution) for later preparation of slides for microscopic examination.

18. The autopsy revealed significant abnormalities in Mr. Van Hook's lungs. The lungs were heavy (left and right lungs weighing 665 and 709 grams, respectively) and showed grossly evident pulmonary edema with cut

sections exuding serosanguineous, frothy fluid. There was bloody froth seen in both main bronchi. No other abnormalities were seen in the lungs. There was evidence of other common natural diseases, including an abnormally small, firm thyroid gland, inflammation in the stomach, and diverticulosis in the colon. The heart appeared normal.

19. Tissue was collected from a variety of organs for microscopic examination. Slides were prepared at the Montgomery County Coroner's Office histology laboratory. This type of histology evidence is the type of material typically reviewed in my field to make conclusions about abnormalities found at autopsy. Histology slides are virtually always produced by a dedicated laboratory and not by the pathologist. I reviewed these slides, and sections of lung confirmed evidence of pulmonary edema with fluid in airspaces, as seen in the images that follow.

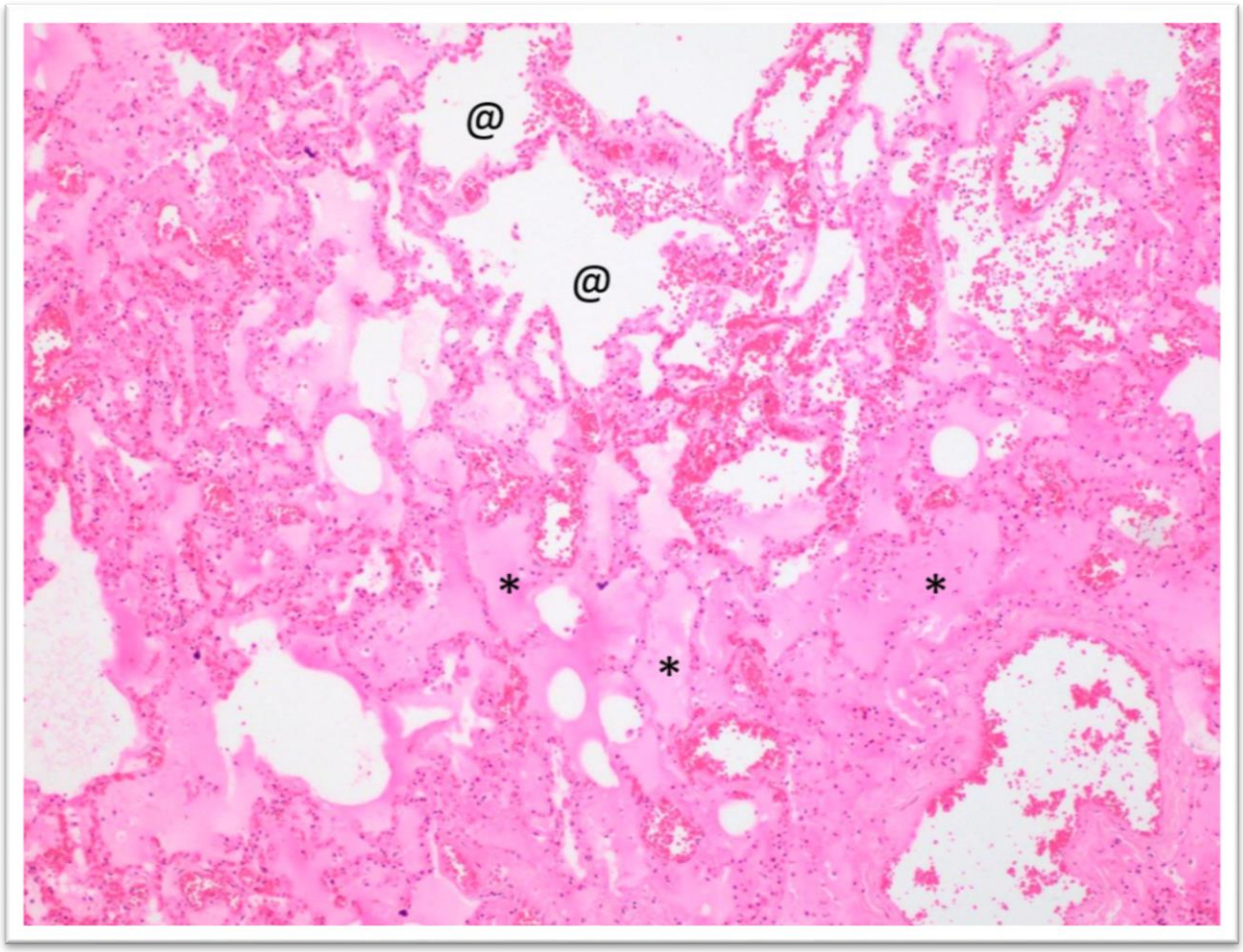

Figure 1 Lung, Hematoxylin and Eosin, 40X AND 100X
The @ identifies an alveolar space filled with air.
The * identifies an alveolar sac filled with pink edema fluid.

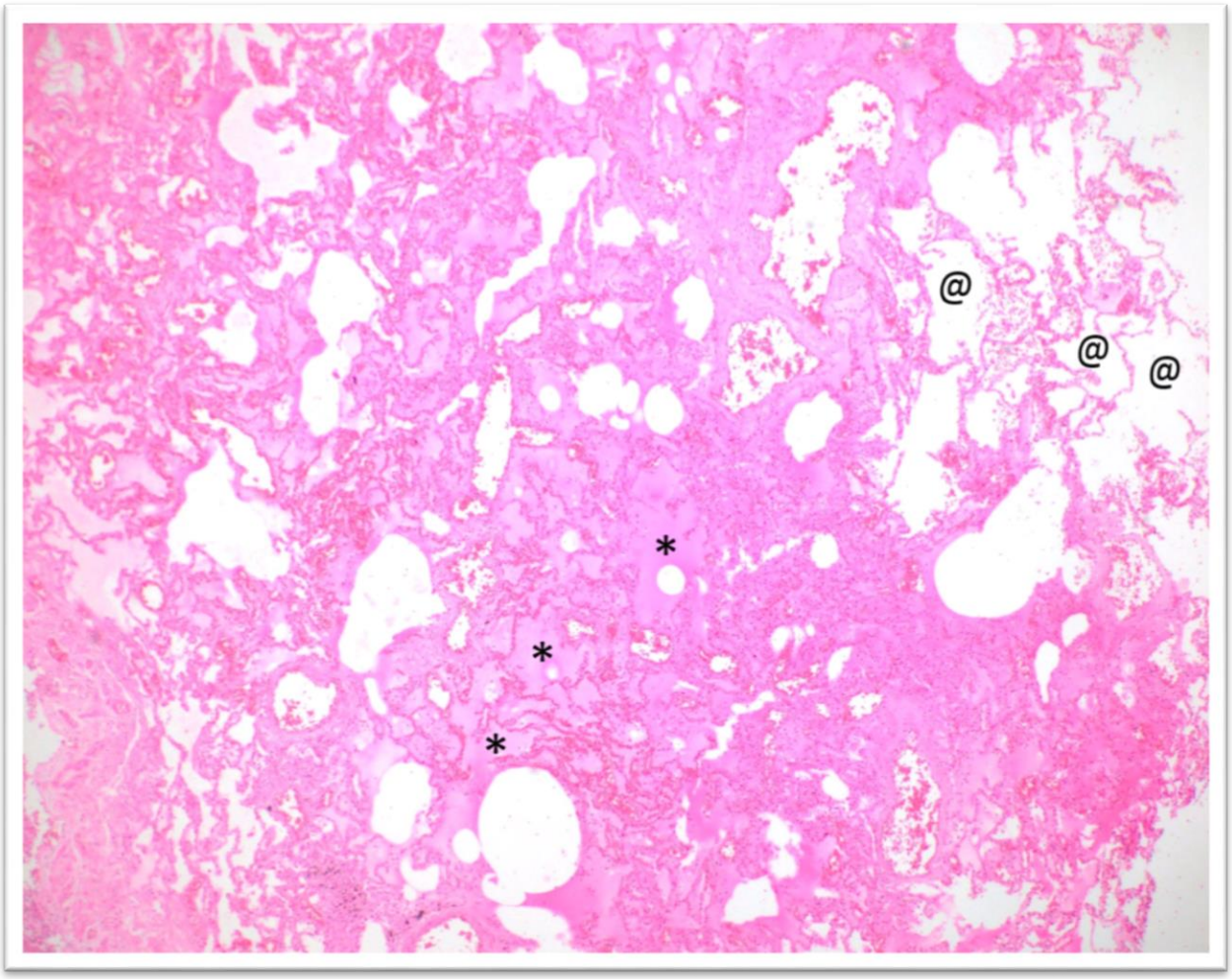

Figure 2 Lung, Hematoxylin and Eosin, 40X AND 100X
The @ identifies an alveolar space filled with air.
The * identifies an alveolar sac filled with pink edema fluid.

20. In addition, microscopic sections of the brain showed evidence of early nerve cell damage resulting from lack of adequate oxygen or blood flow. There was evidence of other common natural diseases such as chronic thyroiditis and fat accumulation in the liver. There was no microscopic evidence of heart disease.

21. After he was administered 500 mg of midazolam, it was reported that Van Hook stopped singing and that his chest was rapidly rising and falling for a few minutes and he fell silent. A minute later, his breathing remained labored. A few minutes later, he began puffing out his lips as he exhaled and then he was gasping and wheezing loudly enough that it was audible into the witness room. A minute or so later, his chest stopped rising and falling. Marty Schladen, Killer's final words: 'I'm no good. I hope now you have some peace', Columbus Dispatch, July 18, 2018, https://www.dispatch.com/news/20180718/killers-final-words-im-no-good-i-hope-now-you-have-some-peace; Cameron Knight, 'I'm no good.' Ohio executes 'homosexual panic' murderer and killer of Hyde Park man, Cincinnati.com, July 17, 2018, https://www.cincinnati.com/story/news/crime/crime-and-courts/2018/07/17/execution-homosexual-panic-murderer-set-10-m/792535002/.

22. The autopsy data confirms my opinion that Van Hook developed acute pulmonary edema during his execution. The portions of the execution eyewitness accounts that simply recount the witness's observations

further support that conclusion; the rapid or labored breathing, gasping, and wheezing described in the eyewitness accounts are typical clinical features of pulmonary edema. In addition, the findings in the brain indicate that Mr. Van Hook was alive for at least 3 to 5 minutes following which time his brain suffered insufficient oxygen delivery or blood flow.

23. Rocuronium bromide would not cause pulmonary edema. In fact, once fully effective, it would prevent the development of frothy fluid in the lungs and airways because as a neuromuscular blocking agent it paralyzes the muscles of respiration which would stop the flow of air necessary for production of froth. (*Journal of Clinical Investigation* 1965; 44(3): 458-464).

24. Potassium chloride would not cause pulmonary edema because it rapidly causes cessation of electrical activity in the heart, cardiac arrest, and cessation of the blood flow necessary for development of pulmonary edema.

25. I also noted that there was no evidence in the autopsy reports or eyewitness observations to suggest that Mr. Van Hook or any of the other executed inmates in whom pulmonary edema was identified post-mortem suffered from pulmonary edema before their respective executions.

26. Because neither the paralytic drug nor the potassium chloride would have been the genesis of the pulmonary edema I found in Mr. Van Hook, and there is no evidence to suggest that the pulmonary edema was present before the execution started, it is my opinion that the 500 mg

dose of IV-injected midazolam was responsible for the development of pulmonary edema in Mr. Van Hook's case. The same applies as to the other cases in which the autopsy reports confirm the presence of pulmonary edema. This is supported by the numerous and consistent eyewitness accounts describing actions indicative of respiratory distress developing relatively early during the execution processes, before administration of the second and third protocol drugs and continuing until some point after injection of the second or third drugs. It is also supported by Dr. Greenblatt's explanation of why and how large doses of IV-injected midazolam, as a highly acidic solution, will rapidly cause damage to the lungs after injection.

III. Other Executions Using Midazolam

27. I have reviewed autopsy reports for all executions for which, to my knowledge, a written autopsy report exists. I have created a spreadsheet of each execution using IV-administered midazolam, charting the autopsy findings related to the presence or absence of pulmonary edema. That chart is attached to this Report as an Exhibit. The written autopsy reports I reviewed are attached to this Report as well. I have also reviewed a spreadsheet with collected eyewitness accounts for each of those executions except the executions of Mr. Van Hook and Mr. Irick. That spreadsheet and the associated citations to the sources are attached to this Report as Exhibits as well. These types of sources, gathering eyewitness observational data and information along with

official records, for the purpose of comprehensive review and analysis, are regularly relied on to reach conclusions in my field. Unless otherwise noted, the references below to matters that occurred during the respective executions can all be found on the associated row in that spreadsheet. My assessment and findings, based on these various sources of information for each of those executions, are as follows.

1. Thomas Arthur (05/26/2017, Alabama, 3-drug midazolam protocol).

28. Eyewitnesses reported that Arthur was administered 500 mg of midazolam at 11:50 p.m., that his breathing became more shallow, and that his breathing remained shallow at least 10 minutes later. The written autopsy report noted his right lung weighed 598 g, and his left lung weighed 470 g. The report also documented that both lungs showed moderately congested parenchyma, and oozed moderate amounts of yellow-tinged frothy fluid. That autopsy data confirms my opinion that Arthur developed acute pulmonary edema during his execution, and the eyewitness accounts further reconfirm that conclusion.

2. Chadwick Banks (11/13/14, Florida, 3-drug midazolam protocol).

29. There is no written autopsy report from Banks's execution. Media accounts of the execution report that Banks "began to breathe deeply" after the drugs began to be injected. It is my understanding that Florida takes steps to tightly bind the inmate's body and extremities, and that Florida injects the paralytic drug quite quickly after injection of the

midazolam. These two factors largely prevent the inmate from outwardly manifesting movements during his execution. As a result, the external observation data from eyewitnesses to Bank's execution (and, with some exceptions, the other Florida executions) are somewhat limited. On the other hand, that also makes the data from Florida executions in which eyewitnesses noticed specific things rather important. Although there is no written autopsy data to say for certain, the eyewitness accounts that Banks exhibited deep breathing means I cannot rule out that Banks developed pulmonary edema during his execution.

3. Oscar Bolin, Jr. (01/07/2016, Florida, 3-drug midazolam protocol).

30. Eyewitness reports of the execution do not describe any activities of note during Bolin's execution. But the pathology data confirm Bolin developed acute pulmonary edema during his execution. The written autopsy report noted his right lung weighed 555 g, and his left lung weighed 680 g. The report noted that both lungs displayed increased firmness, decreased crepitance, and that both were heavy, with congestion and edema. That autopsy data confirms my opinion that Bolin developed acute pulmonary edema during his execution.

4. Christopher Brooks (01/21/2016, Alabama, 3-drug midazolam protocol).

31. Eyewitnesses reported that shortly after he was administered 500 mg of midazolam, Brooks began breathing rapidly and his chest heaved up and down. That chest activity continued for at least three minutes, and he

appeared to remain breathing for at least nine minutes after the midazolam injection. One of his eyes also appeared to open approximately twelve minutes after the midazolam injection. The written autopsy report noted that Brooks's right lung weighed 1020 g, while his left lung weighed 870 g. The report further noted that the major bronchi contained froth, with the lungs oozing large amounts of yellow-tinged frothy fluid. That autopsy data confirms my opinion that Brooks developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

5. Juan Chavez (02/12/2014, Florida, 3-drug midazolam protocol).

32. Eyewitnesses report that after he was administered 500 mg of midazolam, Chavez's eyelids and feet twitched for two minutes. And during that time, he lifted his head slightly and appeared to yawn. The written autopsy report noted Chavez's right lung weighed 900 g, while his left lung weighed 880 g. The report further noted a frothy red fluid oozing from the surface of each lung on manual compression. The autopsy report further noted acute pulmonary congestion and edema upon microscopic examination. That autopsy data confirms my opinion that Chavez developed acute pulmonary edema during his execution.

6. Jerry Correll (10/29/2015, Florida, 3-drug midazolam protocol).

33. Eyewitnesses report that after he was administered 500 mg of midazolam, Correll's body convulsed for approximately 10 seconds, and

then his eyes fluttered and his mouth opened. The written autopsy report noted Correll's right lung weighed 610 g, while his left lung weighed 565 g. The report also noted increased firmness, decreased crepitance, and nonspecific congestion in each lung. That autopsy data is insufficient for me to definitively conclude that Correll developed acute pulmonary edema during his execution, but that cannot be ruled out either.

7. Eddie Davis (07/10/2014, Florida, 3-drug midazolam protocol).

34. Eyewitnesses report that after he was administered 500 mg of midazolam, Davis's chest heaved up and down for more than 5 minutes, and that at one point in the procedure his breath grew shallow. The written autopsy report noted Davis's right lung weighed 1120 g, while his left lung weighed 965 g. Both lungs were noted to ooze froth with slight manual compression, and both showed marked congestion and edema. That autopsy data confirms my opinion that Davis developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

8. Michael Eggers (03/15/2018, Alabama, 3-drug midazolam protocol).

35. Eyewitnesses report that after he was administered 500 mg of midazolam, Eggers showed signs of heavy breathing. The written autopsy report noted Eggers's right lung weighed 1150 g, while his left lung weighed 910 g. The report noted that his upper airways contained

blood-tinged frothy edema fluid, and that lung tissue and intra-pulmonary airways showed blood-tinged edema fluid. That autopsy data confirms my opinion that Eggers developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

9. Ricky Gray (01/18/2017, Virginia, 3-drug midazolam protocol (midazolam and potassium chloride were compounded)).

36. Eyewitnesses report that after he was administered 500 mg of midazolam, Gray began breathing heavily for several minutes. As his breathing became labored, Gray's legs moved, and he started snoring loudly. Approximately 2 minutes after the midazolam injection, Gray is described as taking a giant breath. One minute later, later, he is described as making crying sounds, having stomach movements, snoring, and continued labored breathing. That labored breathing continued for approximately 5 minutes after injection of the midazolam. Witnesses described Gray's head moving from side to side before and shortly after the paralytic drug was injected. The written autopsy report noted Gray's right lung weighed 886 g, while his left lung weighed 715 g. The report also noted foamy liquid in Gray's upper airways. Microscopic inspection also revealed edema fluid and blood in the air sacs, and acute hypoxic ischemic injury in Gray's brain, indicating that he was alive for at least 3-5 minutes after which time his brain suffered impaired oxygen delivery or blood flow. That autopsy data confirms my opinion that Gray

developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts. That the midazolam was compounded does not affect my expert conclusion, because the drug still would have needed to be an acid to be in injectable solution.

10. William Happ (10/15/2013, Florida, 3-drug midazolam protocol).

37. Eyewitnesses report that after he was administered 500 mg of midazolam, Happ moved his head and opened and closed his eyes, and his head twitched. He is also reported to have closed his eyes and then reopened them again a couple minutes after the midazolam injection, and he was still opening his eyes approximately four minutes after that injection. At approximately seven minutes into the execution, Happ began moving his head back and forth, and then his breathing stopped. Head movements are still described at approximately ten minutes into the execution. There are no reports of changes in his breathing, however. The written autopsy report noted Happ's right lung weighed 985 g, while his left lung weighed 825 g. Both lungs were noted to express bloody froth with slight manual compression. Despite no eyewitness reports of Happ showing any changes in his breathing patterns, that autopsy data confirms my opinion that Happ developed acute pulmonary edema during his execution.

11. Robert Hendrix (04/23/2014, Florida, 3-drug midazolam protocol).

38. Eyewitnesses report that after he was administered 500 mg of midazolam, Hendrix's breathing was visible, even under a draped sheet, for about 5 minutes, after which his chest stopped moving. The written autopsy report noted Hendrix's right lung weighed 750 g, while his left lung weighed 595 g. Both lungs were noted to ooze bloody froth with slight manual compression. That autopsy data confirms my opinion that Hendrix developed acute pulmonary edema during his execution.

12. John Henry (06/18/2014, Florida, 3-drug midazolam protocol).

39. Eyewitnesses report that after he was administered 500 mg of midazolam, Henry's breathing and movement slowed. The written autopsy report noted Henry's right lung weighed 735 g, while his left lung weighed 720 g. Both lungs were noted to present with increased firmness and decreased crepitance, and both showed acute congestion and edema. That autopsy data confirms my opinion that John Henry developed acute pulmonary edema during his execution.

13. Robert Henry (03/20/2014, Florida, 3-drug midazolam protocol).

40. There were no specific observations made immediately after Henry was administered 500 mg of midazolam, and it was reported that Henry stopped breathing after the second drug was administered, approximately 5 minutes after the first drug injection. The written autopsy report noted Henry's right lung weighed 815 g, while his left

lung weighed 775 g. The report also noted that sectioned surfaces from both lungs oozed blood and frothy fluid. That autopsy data confirms my opinion that Robert Henry developed acute pulmonary edema during his execution.

14. Paul Howell (03/26/2014, Florida, 3-drug midazolam protocol).

41. Eyewitnesses report that after he was administered 500 mg of midazolam, Howell's left arm and shoulder were visibly moving and twitching, which continued for approximately 15-30 seconds. Witnesses also reported that approximately five minutes after the midazolam was injected, Howell opened his eyes for almost a full minute, and then closed them again. Then, three minutes later, he opened his eyes again and they remained open for the duration of the execution. The written autopsy report noted Howell's right lung weighed 760 g, while his left lung weighed 545 g. The report further noted that Howell's tracheobronchial tree showed pink-tinged froth, and that frothy fluid oozed from both lungs surfaces on compression. Further microscopic inspection also documented acute pulmonary edema and congestion. That autopsy data confirms my opinion that Howell developed acute pulmonary edema during his execution.

15. Billy Ray Irick (08/09/2018, Tennessee, 3-drug midazolam protocol).

42. There is no written autopsy report from Irick's execution. Eyewitnesses report that after he was administered 500 mg of midazolam, Irick did not

close his eyes for approximately a minute. When he did, witnesses described Irick as snoring, breathing heavily, huffing, trying to draw deep breaths, gulping for an extended period of time, choking, gasping, and coughing and that his stomach was moving up and down. One report also noted that his belly protruded from underneath the heavy straps across his chest and that it visibly contracted with each breath. Some minutes after the consciousness checks, Irick is described as letting out a cough or choking sound, as his face turned dark purple, after which he stopped making noise and was soon pronounced dead. Although there is no written autopsy data to say for certain, these eyewitness accounts of Irick's execution lead me to believe that Irick very likely developed acute pulmonary edema during his execution.

16. Jack Jones, Jr. (04/24/2017, Arkansas, 3-drug midazolam protocol).

43. Eyewitnesses report that after he was administered 500 mg of midazolam, Jones's chest was moving up and down for at least five minutes. Eyewitnesses also described his cheeks continuing to move for approximately 7 minutes after the midazolam injection. The written autopsy report noted Jones's right lung weighed 835 g, while his left lung weighed 735 g. The report also documented mild diffuse edematous change in both lungs. That autopsy data confirms my opinion that Jones developed acute pulmonary edema during his execution.

17. Darius Kimbrough (11/12/2013, Florida, 3-drug midazolam protocol).

44. Eyewitnesses reported that Kimbrough's body was tented by a sheet and it was not possible to see movement underneath. The written autopsy report noted Kimbrough's right lung weighed 860 g, while his left lung weighed 590 g. The report documented slight congestion in each lung. Further microscopic inspection revealed marked vascular congestion and mild alveolar edema. That autopsy data confirms my opinion that Kimbrough developed acute pulmonary edema during his execution.

18. Johnny Kormondy (01/15/2015, Florida, 3-drug midazolam protocol).

45. Eyewitnesses report that after he was administered 500 mg of midazolam, Kormondy's chest heaved and his face turned purple. The written autopsy report noted Kormondy's right lung weighed 840 g, while his left lung weighed 620 g. Both lungs were noted to be congested, edematous and to ooze frothy red fluid. That autopsy data confirms my opinion that Kormondy developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

19. Ledell Lee (04/20/2018, Arkansas, 3-drug midazolam protocol).

46. Eyewitnesses report that after he was administered 500 mg of midazolam, Lee appeared to swallow multiple times. The written autopsy report noted Lee's right lung weighed 755 g, while his left lung weighed 660 g. The report noted that both lungs expressed white frothy fluid on

compression. That autopsy data confirms my opinion that Lee developed acute pulmonary edema during his execution.

20. Clayton Lockett (04/29/2014, Oklahoma, 3-drug midazolam protocol).

47. Eyewitnesses report that after he was administered 100 mg of midazolam, at least some amount of which was administered intravenously and some subcutaneously, it was reported that Lockett blinked and occasionally pursed his lips. Approximately 11 minutes after the initial midazolam injection, and continuing on for several more minutes before the witness room curtain was closed, eyewitnesses describe Lockett as doing a host of things, including speaking or mumbling with increasing volume, writhing with increasing violence, bucking, his back arching, his body straining against a restraint of some kind and attempting to get up off the table, breathing heavily, clenching his teeth, straining to lift his head off the pillow, his eyes opening, grimacing, grunting, lifting his entire head and shoulders off the gurney, and rolling his head from side to side. The written autopsy report noted Lockett's right lung weighed 740 g, while his left lung weighed 580 g. The report documented edema in both lungs. Further microscopic inspection confirmed pulmonary edema. That autopsy data confirms my opinion that Lockett developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts of heavy breathing.

48. I should also note that the precise amount of midazolam administered intravenously into Lockett is irrelevant, and the Lockett execution evidence is still useful scientific data for the pulmonary edema question, notwithstanding the botched administration. In fact, that Lockett apparently received *less than* a full 100 mg dose intravenously and still developed acute pulmonary edema during his execution is strong evidence confirming my opinion that intravenous doses of *500 mg or more* of midazolam will be certain or very likely to cause acute pulmonary edema.

21. Dennis McGuire (01/16/2014, Ohio, 2-drug midazolam and hydromorphone protocol).

49. There is no written autopsy report from McGuire's execution. Eyewitnesses report that after he was administered 10 mg of midazolam and 40 mg of hydromorphone, McGuire repeatedly gasped audibly for air, made snorting and choking sounds, as his stomach swelled and distended and he struggled against the restraints on his torso. He was described as looking like a fish lying along the shore puffing for that one gasp of air that would allow it to breathe. The dose of midazolam in this case approximates a therapeutic dose, and McGuire was described as presenting with a body habitus that made it likely he would suffer an obstructed airway as his breathing was suppressed. Those factors make it impossible to ascribe the respiratory distress purely to midazolam or pulmonary edema.

22. Torrey McNabb (10/19/2017, Alabama, 3-drug midazolam protocol).

50. Eyewitnesses report that several minutes after he was administered 500 mg of midazolam, McNabb's breathing quickened. Witnesses also describe McNabb appearing to writhe at almost 10 minutes after the first injection of midazolam, perhaps after a second injection of 500 mg of midazolam. Witnesses also report that at approximately 20 minutes after the initial midazolam injection, McNabb's arm and hand abruptly raised up into the air for several seconds, he visibly grimaced, twisting his head against the gurney, and his feet and legs moved while his lips curled and his brow furrowed. His chest is described as still moving at that point, and those breathing movements continued for approximately another two minutes. The written autopsy report noted McNabb's right lung weighed 430 g, while his left lung weighed 600 g. Usually the right lung is heavier than the left, both in healthy adults and pathologic states, but developmental variations leading to the reverse are occasionally seen and would not affect the validity of conclusions about a process, like pulmonary edema, which diffusely affects both lungs. The report noted that McNabb's major bronchi contained froth, and also noted moderately congested parenchyma. That autopsy data confirms my opinion that McNabb developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

23. Robert Melson (06/08/2017, Alabama, 3-drug midazolam protocol).

51. Eyewitnesses report that after he was administered 500 mg of midazolam, Melson exhibited labored breathing for approximately 7 minutes before his breathing slowed, after which the second and third drugs were administered. The written autopsy report noted Melson's right lung weighed 680 g, while his left lung weighed 540 g. The report documented mild vascular congestion and normal crepitus in both lungs. That autopsy data is insufficient for me to definitively conclude that Melson developed acute pulmonary edema during his execution, but that cannot be ruled out either. The eyewitness description of labored breathing for approximately 7 minutes is, however, quite consistent with Melson developing acute pulmonary edema during his execution. Microscopic examination might have clarified that, but no microscopic examination was performed.

24. Walter Moody (04/19/2018, Alabama, 3-drug midazolam protocol).

52. Eyewitnesses report that after he was administered 500 mg of midazolam, Moody's chest moved during the early part of his execution, and that he appeared to move a few of the fingers on his left hand after the consciousness test. The written autopsy report noted Moody's right lung weighed 780 g, while his left lung weighed 980 g. The report documented congestion in both lungs, and further microscopic examination revealed mild interstitial anthracosis (dust particles). That

autopsy data is insufficient for me to definitively conclude that Moody developed acute pulmonary edema during his execution, but that cannot be ruled out either. The eyewitness descriptions are likewise insufficient to determine whether Moody developed acute pulmonary edema during his execution.

25. William Morva (07/06/2017, Virginia, 3-drug midazolam protocol (involved compounded drugs).

53. Eyewitnesses report that after he was administered 500 mg of midazolam, Morva appeared to be speaking for a few minutes, and that he made a loud sound like a hiccup. Witnesses recount that Morva developed deep breathing and that his diaphragm contracted sharply several times. The written autopsy report noted Morva's right lung weighed 800 g, while his left lung weighed 628 g. The report also documented that Morva's upper airway was filled with a moderate amount of froth. Further microscopic examination showed no abnormalities in lungs and also revealed scattered hypoxic/ischemic neurons in the hippocampus, an indication that the inmate was alive for more than 3-5 minutes, after which time his brain was deprived of adequate blood flow or oxygen delivery. The presence of unequivocal gross evidence of pulmonary edema indicates that sections submitted for histology were likely not taken from dependent portions of the lung where edema would be more apparent. That autopsy data confirms my opinion that Morva developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

26. Askari Muhammad (Thomas Knight) (01/17/2014, Florida, 3-drug midazolam protocol).

54. There is no written autopsy report from Muhammad's execution. Eyewitnesses report that after he was administered 500 mg of midazolam, Muhammad's breathing slowed, and he kept his eyes closed, but that he opened one of his eyes at some point after the second and third drugs were administered. The eyewitness accounts do not describe compelling signs of pulmonary edema, although this was a Florida execution, meaning the inmate is tightly bound and covered, and the paralytic drug is injected extremely quickly after the midazolam injection. Accordingly, the absence of external evidence that he developed pulmonary edema cannot be interpreted as evidence that he did not. It is not possible to confirm or exclude that pulmonary edema was present given the lack of eyewitness reports of external evidence and the absence of an autopsy report.

27. Gary Otte (09/13/2017, Ohio, 3-drug midazolam protocol).

55. There is no written autopsy report from Otte's execution. Eyewitnesses report that after he was administered 500 mg of midazolam, Otte's stomach moved up and down unnaturally and he appeared to have developed obstructive breathing. Witnesses describe Otte as having tearing from his eye or eyes, his stomach heaving violently for several minutes, rising and falling several times in the first minute or two after the midazolam injection. Otte's stomach is described as continuing to rise and fall for a couple more minutes even following the consciousness

check, until his breathing stopped after the paralytic was injected. Although there is no written autopsy data to say for certain, the eyewitness accounts of Otte's execution lead me to believe that Otte may have developed acute pulmonary edema during his execution, based on his stomach heaving violently for several minutes. It is also possible that the obstructive breathing in this case may have caused a component of negative-pressure pulmonary edema, which would have caused similar severe pain and horrific suffering regardless of the different genesis of the edema.

28. Ronald Phillips (07/26/2017, Ohio, 3-drug midazolam protocol).

56. There is no written autopsy report from Phillips's execution. Eyewitnesses report that after he was administered 500 mg of midazolam, Phillips began to breathe deeply and developed an obstructive pattern of breathing, with his stomach visibly moving. Although there is no written autopsy data to say for certain, the eyewitness accounts of Phillips's execution lead me to believe that Phillips very likely developed acute pulmonary edema during his execution based on the abrupt change in his pattern of breathing shortly after the administration of midazolam.

29. Ronald Smith (12/08/2016, Alabama, 3-drug midazolam protocol).

57. Eyewitnesses report that after he was administered 500 mg of midazolam, Smith developed difficulty breathing/struggling for breath,

heaved, and produced regular asthmatic-sounding barking coughs and gasping respiration. He is reported to have lifted his head and looked around after the midazolam injection, moved his arms and clenched and unclenched his hand, and moved his arms and chest. Eyewitnesses report that Smith coughed regularly for at least 15 minutes after the midazolam injection, lasting until the paralytic was injected, and that Smith's eyes were open and he attempted to mouth words during a consciousness check 5 minutes after the first midazolam injection. Smith is reported to have continued coughing and gasping after what is believed to be a second 500 mg dose of midazolam was injected. He exhibited similar reactions to the second dose as to the first dose, lifting his head, struggling, clenching and unclenching his hands while mouthing words. Witnesses describe Smith's fist clenching and unclenching after a second consciousness check following the second midazolam dose. His movements did not stop until after the paralytic was injected. The written autopsy report noted Smith's right lung weighed 850 g, while his left lung weighed 920 g. The report documented congestion in both lungs, and further microscopic examination revealed pigmented macrophages and mucus plugs in the bronchioles. That autopsy data is insufficient for me to conclude that pulmonary edema developed during his execution, but that cannot be ruled out either. The eyewitness description of struggling for breath, gasping, and coughing for a lengthy period of time following the initial midazolam dose is consistent

with Smith developing acute pulmonary edema during his execution. My conclusions do not change even if we presume that Smith received a second dose of 500 mg of midazolam administered intravenously.

30. Robert Van Hook (07/18/2018, Ohio, 3-drug midazolam protocol).

58. See Section II above.

31. Charles Warner (01/15/2015, Oklahoma, 3-drug midazolam protocol (third drug was potassium acetate)).

59. Eyewitnesses report that after he was administered 100 mg of midazolam, Warner said "my body is on fire." The written autopsy report noted Warner's right lung weighed 550 g, while his left lung weighed 550 g as well. The report also documented that Warner's lungs were both congested and edematous, and that both lungs exuded a moderate amount of clear frothy fluid. Further microscopic examination also confirmed congestion and edema. That autopsy data confirms my opinion that Warner developed acute pulmonary edema during his execution. That Oklahoma injected Warner with potassium acetate, not potassium chloride as the applicable execution protocol required, does not affect my conclusion. Additionally, Warner's statement after injection of the midazolam but before injection of the paralytic or potassium acetate is strong evidence showing that it is certain or very likely that Warner felt the severe burning of that large dose of acidic midazolam as it activated pain receptors in his veins.

32. Kenneth Williams (04/27/2017, Arkansas, 3-drug midazolam protocol).

60. Eyewitnesses report that after he was administered 500 mg of midazolam, Williams was coughing, convulsing, jerking, struggling for air, and made audible noises like gasping or straining for breath. He was observed heaving and choking with his chest pumping up and down, his cheek muscles moving, his head bobbing, and his breathing was described as labored. Witnesses report that he audibly groaned 2-3 minutes after the midazolam injection, and he was forcibly rising from the gurney while repeatedly and rhythmically convulsing. Approximately 3 minutes after the midazolam injection, Williams's body is described as jerking approximately 15 times in rapid succession over 10-15 seconds before moving 5 more times at a slower rate, after which he continued to have labored breathing. Witnesses describe Williams as audibly groaning after the consciousness check 5 minutes after the midazolam injection, as his head still bobbed, and then he groaned again. Witnesses also reported that approximately 7 minutes after the midazolam injection began, and following the consciousness check, his heavy breathing that was seen for approximately four minutes came to an end, at least visibly. The written autopsy report noted Williams's right lung weighed 590 g, while his left lung weighed 555 g. The report also documented that there was serosanguineous fluid identified in Williams's nares, oral cavity, and upper and lower airways. As the autopsy report did not identify another source for the blood-tinged fluid and since it primarily occupied the

respiratory passages, I conclude that it originated as froth from edematous lungs that rose into the airways, mouth and nose and then dissipated, leaving fluid. That autopsy data confirms my opinion that Kenneth Williams developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

33. Marcel Williams (04/24/2017, Arkansas, 3-drug midazolam protocol).

61. Eyewitnesses report that after he was administered 500 mg of midazolam, Williams developed deep and heavy breathing and that he sucked in air as he repeatedly arched his back countless times over approximately 5-6 minutes. The written autopsy report noted Williams's right lung weighed 750 g, while his left lung weighed 720 g. The report also documented that there was abundant watery secretion identified in Williams's nares, oral cavity, and upper and lower airways. As the autopsy did not identify another source for the fluid, I conclude that it originated as froth from edematous lungs that rose into the airways, mouth and nose and then dissipated, leaving fluid. That autopsy data confirms my opinion that Marcel Williams developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

34. Joseph Wood (07/23/2014, Arizona, 2-drug midazolam and hydromorphone protocol).

62. Eyewitnesses report that after he was administered 50 mg of midazolam along with 50 mg of hydromorphone, Wood gasped (as he would more

than 600 times over the ensuing hour and forty minutes), his breathing became heavier, and then approximately 1 minute later his breathing shallowed as he turned his head to the left and then to the right, and began licking his lips. Witnesses report that approximately twelve minutes after the first injection, Wood yawned, took a big breath, strained against the restraining straps, and gasped. Additional gasping, straining, yawning, and heavy gulping, gasping breaths and struggling efforts to breathe reportedly continued for an extended period of time. Eventually he gulped like a fish on land and made snoring and sucking noises. And when he was injected with 14 additional doses of 50 mg of midazolam and 50 mg of hydromorphone over the next 96 minutes, Wood was described as gasping for air and struggling to breathe throughout that time.

63. The written autopsy report noted Wood's right lung weighed 980 g, while his left lung weighed 945 g. The report also documented that both lungs exuded blood and marked amounts of bloody, frothy fluid. Further microscopic examination revealed that both lungs showed hemorrhagic pulmonary edema. That autopsy data confirms my opinion that Wood developed acute pulmonary edema during his execution, which is further supported by the eyewitness accounts.

64. That Wood was administered midazolam in conjunction with hydromorphone may have had a confounding effect on witness observations, but there is no reason to believe that it would contribute to

the presence of pulmonary edema. If anything, I believe it powerfully suppressed Wood's efforts to breathe due to the synergistic effect between midazolam and hydromorphone. That means the outward manifestations of vigorous gulping, gasping, coughing, and otherwise struggling to breathe would have been even more pronounced without it.

65. Additionally, regardless of whether the Wood execution is directly probative of the risks associated with the second and third drugs in Ohio's three-drug protocol, it is immensely important scientific evidence demonstrating that large doses of IV-injected midazolam are sure or very likely to cause acute pulmonary edema.

66. Indeed, the Wood execution is arguably the best experimental, scientific evidence that exists on that point; it vividly demonstrated the results on the body of an IV-injected dose of 500 mg or more of midazolam, first externally as outward bodily movements and other manifestations, and then internally via autopsy data. It involved at least 750 mg, injected intravenously, without any question of administration problems.

67. Just as important from a scientific, evidence-gathering perspective, there was no artificial, chemical concealment of what large (extra-clinical) doses of IV-injected acid do to the lungs; there was no injection of the paralytic drug very shortly afterwards, like occurred in the Ohio and Florida executions discussed here, nor any injection of the paralytic after a longer wait period as in Alabama or Arkansas or Oklahoma. Likewise, unlike the situation in some states like Alabama or Florida, there were

no artificial concealment in the form of tightly binding the inmate or covering him with a sheet to restrict visible movements or to obscure observation of such movements.

68. The Wood execution was a raw science experiment playing out in real time. It was an unfiltered, outward manifestation of acute pulmonary edema for an extended duration. And that fact was then irrefutably confirmed by post-mortem autopsy evidence.

SCIENTIFIC BASES AND OPINIONS REGARDING SCIENTIFIC DATA COLLECTION AND USAGE, AND OTHER MATTERS OF SCIENTIFIC CONSENSUS

69. I have reviewed the opinions issued by the courts in *Glossip vs Gross*, *Baze vs Rees*, *Abur'Rahman*, and in this case.

70. Insofar as the Ohio lethal injection protocol is intended to smoothly render inmates insensate prior to administration of drugs that will sequentially stop breathing and heartbeat, the autopsy data and witness observations indicate that it achieves a different result. Descriptions of respiratory distress, recounted in detail above, have been noted for some time in the 3-drug midazolam protocol, but always observed and analyzed through the particular lens of the second and third drugs in the protocol. Now, however, that evidence must be reassessed through a new and different lens. The presence of an anatomic cause has only become known with review of autopsy data presented here, evidence that was not previously available, especially when it continues to accumulate with each new execution involving IV-injected large doses of midazolam.

71. The word autopsy means "to see for one's self", and what forensic pathologists from multiple states independently and repeatedly saw and reported was scientific autopsy evidence of acute, often fulminant, pulmonary edema that could only be attributable to the large doses of IV-injected midazolam. This conclusion is based on the facts that 1) neither rocuronium bromide nor potassium chloride would produce pulmonary edema; 2) a paralytic such as rocuronium would cause cessation of air flow necessary to generate froth in the lungs and airways, and 3) witness observations document frequent evidence of respiratory distress after the large volume of midazolam is injected (and prior to injection of the second and third drugs). Midazolam is maintained in solution by addition of sufficient hydrochloric acid to maintain a highly acidic pH of 3.0-3.6 (normal body pH is 7.4). Intravenous injection of large amounts of acid solutions is known to produce acute lung injury with pulmonary edema in animal models (Ikram U et al. Intravascular infusion of acid promotes intrapulmonary inducible nitric oxide synthase activity and impairs blood oxygenation in rats. Critical Care Medicine 2003; 31: 1454-1460 and Am J Respir Crit Care Med 1999: 159: 397-402). Extrapolating the scientific conclusions from these studies reconfirms my conclusions identified by the overwhelming number and consistency of post-execution autopsies; large doses of IV-injected midazolam, including the 500 mg dose Ohio uses, are unquestionably and surely causing acute lung injury in the form of pulmonary edema in the condemned inmates

from the very start of the execution protocol's administration. It is sure or very likely that the inmates will develop acute pulmonary edema following the initial injection in Ohio's three-drug midazolam protocol.

72. I also note the Court's previous statement that new evidence from recent executions that is consistent with evidence from older executions previously considered is cumulative and thus insignificant or irrelevant. But in science and medicine each new supportive observation adds strength to a hypothesis (Swiss Med. Wkly. 2012;142:w13518), and cumulative evidence is highly valued, indeed so much so that studies of studies (i.e. meta-analyses) bearing on the same issue or question are routinely performed to help guide medical and scientific opinion. The presence of pulmonary edema in the vast majority of this relatively large series of autopsies in combination with repeated witness observations of respiratory distress following administration of midazolam is consistent, cumulative evidence strongly supporting the conclusion that large amounts of this drug injected during the 3-drug protocol are responsible for diffuse lung injury manifesting as pulmonary edema.

SOME ASSERTIONS CONTAINED IN DEFENDANTS' MEMORANDUM IN OPPOSITION ARE MISLEADING OR INCORRECT.

73. I have reviewed the Memorandum In Opposition the Defendants filed in this case. (ECF No. 1934.) In that document, the Defendants make several arguments in reference to my opinions which are either misleading or simply incorrect.

74. Defendants argue that review of autopsy reports pertaining to pentobarbital executions showed the same findings (*i.e.*, pulmonary edema) as in this series of autopsies from executions using midazolam. But they do not explain how this undermines my conclusions here in any way. Indeed, similar autopsy findings should not be surprising given that pentobarbital has a very alkaline pH of 9.5, much higher than normal blood pH of 7.4. When inadvertently injected into tissue other than a vein, it is known to be able to cause severe tissue damage; injection into an artery can result in gangrene affecting the limb supplied by that artery. (Pentobarbital package insert, Leucadia Pharmaceuticals.) Rather than weakening the significance of the findings of pulmonary edema during IV-injected midazolam executions, this adds support to my conclusion that the IV injection of a large volume of fluid with a highly abnormal acidic or alkaline pH exerts a caustic effect on lung tissue.

75. Defendants correctly point out that I previously declined to offer an opinion "that the prisoners were sure or very likely to suffer serious pain as a result of midazolam-caused pulmonary edema." I have indicated my opinion, based on my professional training, education, and experience as a medical doctor, that acute pulmonary edema results in serious, terrifying pain and suffering in the general population; this is well known to physicians and medical students. But as my expertise is in anatomic pathology, I am not qualified to opine on the pain perception of a

prisoner suffering from midazolam-induced pulmonary edema due to a 500 mg intravenous bolus of this acidic drug, other than to state that pulmonary edema is, without question, sure or very likely to occur with Ohio's three-drug midazolam protocol and, if the prisoner is experiencing it, the pain would surely be severe, the suffering surely horrific. It is also my understanding that Henness will present other experts who are well-qualified to opine on these matters, including on the question whether it is sure or very likely the inmate will experience the severe pain and horrific suffering from the acute pulmonary edema that will develop. I have no reason to disagree with that opinion.

76. Additionally, Defendants seem to place significance in the notion that there are no scientific studies on the sedative effects of a massive overdose of midazolam. But while there may not be a peer-reviewed journal article about it, Defendants overlook the scientific experiment that was done on Joseph Wood which directly informs the pulmonary edema question here. That evidence is unique, and no evidence to the contrary exists. Furthermore, there is indeed published scientific literature on the lung injury caused by intravenously infused hydrochloric acid, which is the chemical additive used to maintain midazolam in solution. (*Critical Care Medicine* 2003; 31: 1454-1460; *Am J Respir Crit Care Med* 1999; 159: 397-402). The result is diffuse lung injury, which is consistent with the evidence from executions discussed here.

77. I also note that this Court, the Sixth Circuit, and the Supreme Court have relied on the understanding that it was a fact that there were 12 executions using midazolam that were apparently without problems, including 11 in Florida and the Warner execution in Oklahoma. But my review of the autopsy evidence from those executions, along with reconsideration of the timing and thus the significance of Warner's statement that "my body is on fire," conclusively demonstrates that is not true. I have identified, by untested autopsy finding, that acute pulmonary edema developed in 11 of those 12 executions. Also, Warner's statement, while not bearing effects from the second or third drugs in the protocol, is direct, first-person evidence of what Warner was feeling following the injection of highly acidic midazolam.

CONCLUSION

78. My expert opinions are contained throughout this report. Some of them are reiterated as follows.

79. It is my expert opinion, based on autopsy data, that the condemned inmates developed acute pulmonary edema in 24 out of 28 executions in which IV-injected midazolam was used as part of the execution protocol.

80. It is my expert opinion that the 11 Florida executions and 1 Oklahoma execution previously described as having been without problems cannot accurately be described as such, because acute pulmonary edema is confirmed at autopsy in 11 of those 12 executions, and the Oklahoma

execution included the inmate describing that his body was on fire following the midazolam injection.

81. It is my expert opinion that the primary cause of the pulmonary edema identified in these executed inmates is the relatively rapid IV injection of a large dose of midazolam in a highly acidic form, which enters the lungs almost immediately after injection and promptly begins to destroy the delicate blood vessels in the lungs, thereby causing the lungs to immediately begin to fill with fluid and blood.

82. It is my expert opinion that acute pulmonary edema is a terrifying, horrific and painful condition that causes great suffering as the person struggles to breathe without being able to exchange air because of the compromised lungs.

83. It is also my expert opinion that in those execution cases in which acute pulmonary edema was not documented in a written autopsy report, the absence of such evidence does not prove those inmates did not develop acute pulmonary edema because subtle macroscopic evidence of pulmonary edema could easily be overlooked if not specifically sought.

84. Further, it is my expert opinion that those other executed inmates very likely developed acute pulmonary edema that could have been identified in a microscopic examination of properly prepared histology slides.

85. It is my expert opinion that injecting large doses of midazolam intravenously will cause severe burning sensations in the blood vessels due to the highly acidic nature of midazolam in injectable solution form.

86. Based on my current understanding of the data from executions using midazolam, my understanding of the scientific literature and research, my personal experience involving the Van Hook autopsy, and my understanding of how Ohio carries out its three-drug execution protocol, it is my expert opinion that an inmate who is subjected to Ohio's three-drug midazolam execution protocol, including Plaintiff Henness, is certain or very likely to experience acute pulmonary edema after peripheral IV injection of 500 mg or more of midazolam.

87. It is my expert opinion that unless rendered insensate by a drug that either deeply depresses brain function or otherwise prevents perception of pain, inmates subjected to a 500 mg intravenous injection of midazolam would experience severe respiratory distress with associated sensations of drowning, asphyxiation, panic and terror.

88. I hold the opinions expressed throughout this expert report to a high degree of medical and scientific certainty. I understand that discovery remains ongoing, and I reserve the right to amend or supplement my report upon provision of additional information that so warrants, including but not limited to deposition testimony and additional documents.

I declare under penalty of perjury that the foregoing is true and correct.

Dated: Oct. 26, 2018

Atlanta, Georgia

/s/ Dr. Mark Edgar, M.D.
Dr. Mark Edgar, M.D.
10/26/2018

Curriculum Vitae

Mark Allen Edgar

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DEGREES: B. Sc. *cum laude* (Psychology), Dalhousie University, Halifax, Nova Scotia, Canada, 1984.

M.D. *cum laude*, Dalhousie University, Halifax, Nova Scotia, 1988.

APPOINTMENTS:

Associate Professor of Pathology, Emory University School of Medicine, September 2010 - present

Assistant Director Emory Bone and Soft Tissue Pathology Service, 2010 – present

Staff Pathologist, CellNetix Laboratories, Seattle, WA, 9/2008-8/2010.

Associate Clinical Member, Memorial Sloan-Kettering Cancer Center (Hospital Appointment) Hospital, July 2004 – August 2008

Associate Attending Pathologist (Anatomic Pathology and Neuropathology), Memorial Sloan-Kettering Cancer Center, New York, NY (2004-2008)

Associate Professor of Clinical Pathology, Weill Medical College of Cornell University, New York, NY (2000-2008)

Assistant Professor of Clinical Pathology, Cornell University Medical Center (1995-2000)

LICENCES AND PROFESSIONAL MEMBERSHIPS:

Licentiate of the Medical Council of Canada, 1988

Licentiate of the National Board of Medical Examiners of USA, 1989

Diplomate, Royal College of Physicians and Surgeons of Canada (Anatomic Pathology), 1993

Diplomate, American Board of Pathology (Anatomic Pathology, 93-206)

Diplomate, American Board of Pathology (Neuropathology, SQ 95-056)

Affiliate Member, American Association of Neuropathologists

Member, International Society of Neuropathology

Member, United States and Canadian Academy of Pathology

Member, New York Bone Pathology Club (2004-2008)

Member, International Society of Bone and Soft Tissue Pathologists

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EDUCATION:

1984-1988	Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia
1981-1984	Faculty of Arts and Science, Dalhousie University, Halifax, Nova Scotia (B.Sc. psychology)

AWARDS AND SCHOLARSHIPS

2012	Golden Apple Award for Resident Teaching, Emory Pathology Residents
2003	Senior List, graduating Cornell Medical College Class of 2003
2002	Excellence in Teaching Award, Cornell Medical College
2002	Honorary Member, Alpha Omega Alpha Medical Honor Society
1996	Citation: Participation in NJ Summer Scholars Program
1993	Outstanding Resident Award, Anatomic Pathology

1988 W.H. Hattie Prize in Internal Medicine

1988 Poulenc Prize

1988 R.O. Jones Prize in Psychiatry

1988 Lange Book Prize

1986 Ross Stewart Smith Medical Scholarship

1985 Ross Stewart Smith Medical Scholarship

1984 Avery Prize

1983 Ross Stewart Smith Undergraduate Scholarship

1982 Marjorie F Ellis Scholarship

1981 Dalhousie Arts and Science Entrance Scholarship

INTERNSHIP:

Rotating Intern, Mount Sinai Hospital, Toronto, Ontario, 1988-1989

RESIDENCY TRAINING:

Anatomic Pathology Residency Training Program, Dalhousie University, Halifax, Nova Scotia, 1990-1993

Chief Resident in Pathology, Victoria General Hospital, 1991-1993

Neuropathology Residency Training Program, Massachusetts General Hospital, Boston, Massachusetts, 1993-1995

UNDERGRADUATE TEACHING RESPONSIBILITIES:

General Pathology lectures, VGH School of Cytotechnology, Cell Injury and Inflammation, 1990-1993

Med II Seminars, General Pathology, Cell Injury, Inflammation, Infarction, and Neoplasia, 1989-1993

Med II Laboratory Instructor, Systems Pathology (Gastrointestinal and Gynecologic), 1991-1993

Med II Lectures in Systems Pathology (Hematopathology), Dalhousie Medical School, 1992

Med II Lectures in General Pathology (Cell Injury), Dalhousie Medical School, 1992

Laboratory Instructor and Oral Examiner, Human Nervous System and Behavior Course, Harvard University Medical School, 1993

Laboratory Instructor, Neuroanatomy, Harvard Medical School HST Course, Fall 1994

Laboratory Instructor, Second Year Pathology Course, Cornell University Medical College, 1995-1999

Tutor, Neurology Problem - Based Learning Pilot Course, Cornell University Medical College, Spring 1996

Neuropathology Lectures, Second Year Medicine, Cornell Medical College, Fall and Winter 1997

Neuropathology Lecture, Degenerative and Metabolic Diseases, New York Medical College, Valhalla, Spring, 1996 and 1997

Neuropathology Lectures and Labs, Brain and Mind Course, Second Year Medicine, Cornell Medical College, Fall, 1998 – 2003

Neuropathology Lecture, Cornell Physician's Assistant Class, 1996-2001

Basis of Disease Course, Cornell Second Year Medicine, Problem-Based Learning Sessions and Triple Jump Exam, Winter 2002-3 (Respiratory, Cardiac, and Renal Sections).

Basis of Disease Course, Cornell Second Year Medicine, Problem-Based Learning Sessions and Triple Jump Exam, Winter 2003-4 (Respiratory, Cardiac, and Renal sections).

Medical Student Clinical Lab Experience, Laboratory tours and teaching (1 day), Emory University Medical School, 2010-2014

Bone Tumor Basics, Emory SOM Year 2, 2014-2018

OTHER TEACHING:

Neuropathology Conference for Neurology staff and students, Memorial Hospital, biweekly (2004-2007); monthly to 2008.

Neuropathology Review Conference, Memorial Sloan-Kettering BTC, monthly, October 2007 to July 2008.

Neuropathology Conference for Neurosurgery staff and students, Memorial Hospital, monthly (2004-2008).

Memorial Hospital Orthopedic fellows pathology teaching (monthly, at multi-headed microscope), 2004-2008.

Bone and Soft Tissue: Common Tumors, Weill-Cornell Pathology Residents, twice a year slide seminar, 2005 to 2008.

COMMITTEES:

Resident Member, Anatomic Pathology Residency Training Committee, Dalhousie University, 1990-1991.

Neuropathology Advisor, Brain and Mind Course Development Committee, (Second Year Medicine) Cornell Medical School, 1997 - 2003.

Anatomic Pathology Quality Assurance Committee, Weill-Cornell Medical Center (2002 to 2004).

Pathology Resident Selection Committee, Weill-Cornell Medical Center (2001 to 2004).

Pathology Residency Committee, Weill-Cornell Medical center, 2003-4.

Chairman, Pathology Quality Assessment Committee, Memorial Sloan-Kettering Cancer Center, 2004 to 2008.

Pathology Representative, Surgical Quality Assessment Committee, Memorial Sloan-Kettering Cancer Center, May 2005 to 2008.

Fellowship Committee, Memorial Sloan-Kettering Pathology Department, 2005 to 2008.

Chariman, Pathology QA Committee, Emory Department of Pathology, 2010-present.

PRESENTED PAPERS:

Pulmonary Lymphangioleiomyomatosis: Pathologic Findings in Two Cases. Resident presentation, Canadian Association of Pathologists Annual Meeting, Toronto, 1992.

Mesenteric panniculitis: autopsy findings in three cases. Resident Presentation, Canadian Association of Pathologists Annual Meeting, Toronto, 1992.

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Lobar atrophy with Lewy bodies. American Association of Neuropathologists Annual Meeting, June 10-15, 1997, Pittsburgh, Pennsylvania.

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Convection-enhanced delivery into the brain stem: an animal model. Sandberg D, Edgar M, and Souweidane MM. Congress of Neurological Surgeons, San Diego, CA, Sept 29 – Oct 4, 2002.

Convection-enhanced delivery into the rat brainstem: a potential delivery mechanism for the treatment of diffuse pontine gliomas. Sandberg D, Edgar M, and Souweidane MM AANS/CNS Section on Pediatric Neurosurgery, New York, NY, Nov 28 – Dec 1, 2001.

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PUBLICATIONS:

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BOOK CHAPTERS

Spinal Vascular Malformations in *Operative Techniques in Neurosurgery* Vol 6, Issue 3: 122-124, September 2003.

Benign Nerve Sheath Tumors in *Orthopedic Knowledge Update: Musculoskeletal Tumors 2*, Herbert S. Schwartz, ed. American Academy of Orthopedic Surgeons, 2007.

INVITED PRESENTATIONS:

Postmortem Diagnosis of Neurodegenerative Disorders. Short Course 09, USCAP Annual Meeting 1999 - 2002 with MJ Ma, MD, PhD and JP vonSattel, MD.

Moderator, Neuropathology Section, Proffered Papers, USCAP Annual Meeting, New Orleans, LA, March 2000.

Neuroscience Grand Rounds, Memorial Sloan-Kettering Cancer Center, NY, March 20, 2001. Oligodendroglioma: One Neuropathologist's Perspective.

Immunohistochemistry in Brain Tumor Diagnosis and Prognosis. Society for Applied Immunohistochemistry, 4 October 2003.

Human Neurodegenerative Diseases: Immunohistochemistry in Diagnosis. Society for Applied Immunohistochemistry, 4 October 2003.

WHO 2000 Classification of Brain Tumors. Annual Spring Meeting of The New York Roentgen Society, 14 April 2004, Rockefeller University.

WHO Classification of Brain Tumors. Brain Tumors: Advances in Diagnosis & Treatment, A Comprehensive Review (Cornell). New York Grand Hyatt, 8 November 2004.

Intraoperative Smear Cytology in Neuropathology. Evolution of Cytopathology, Memorial Sloan-Kettering Cancer Center, NY, 21 November 2004.

Intraoperative Smear Cytology in Neuropathology. Pathology Grand Rounds, Long Island Jewish Hospital, NY, 13 January 2005.

Skeletal Metastases. Pathology Refresher Course, International Skeletal Society Annual Meeting, Singapore, 29 September 2005.

Update on Pathology and Genetics. Advances in Neuro-Oncology, Memorial Sloan-Kettering Cancer Center, NY, Department of Neurology 30th Anniversary, 21 October 2005.

Subspecialty Conference: Neuropathology. US and Canadian Academy of Pathology Annual Meeting, Atlanta, GA, February 2006 (presented *in absentia* by Dr. Gregory Fuller during The Blizzard of 2006).

Subspecialty Conference: Neuropathology. US and Canadian Academy of Pathology Annual Meeting, San Diego, CA, March 2007.

Surgical Pathology of Neoplastic Diseases; MSKCC 25th Anniversary Course. May 9: Case Presentation; May 11: Intraoperative Smear Cytology of CNS Lesions (for Dr. Marc Rosenblum).

Epithelioid Vascular Tumors of Soft Tissue and Bone. Moffitt Cancer Center, Tampa, Florida; 15 April 2008.

Intraoperative Smear Cytology of CNS lesions. CellNetix Pathology, Seattle, WA; 18 April 2008.

Bone and Soft Tissue Tumors of the Head and Neck. The Surgical Pathology of Neoplastic Diseases, Memorial Sloan-Kettering Cancer Center, New York, NY; 14 May 2008.

Spindle Cell Tumors of the Breast. The Surgical Pathology of Neoplastic Diseases, Memorial Sloan-Kettering Cancer Center, New York, NY; 15 May 2008.

What's New and Neuronal: Brain Tumor Update. PSPH Olympia Neurosurgery Grand Rounds, Olympia WA; 6 February 2009

Epithleioid Tumors of Bone and Soft Tissue. WSSP Meeting, Seattle, WA February 7, 2009.

Notochordal and Related Lesions. Moffitt Cancer Center, Tampa, FL; 2 June 2009.

Bone and Soft Tissue Tumors: an Update. Duckworth Pathology Group Continuing Medical Education, Memphis, TN, 19 February 2011

Bone Tumor Basics. Emory Orthopedic Surgery Grand Rounds, Atlanta, GA, 1 May 2012.

OTHER ACTIVITIES:

Ad hoc reviewer:

American Journal of Pathology
American Journal of Dermatopathology
Annals of Surgical Oncology
Applied Immunohistochemistry and Molecular Morphology
Children's Brain Tumor Foundation
Cutaneous Pathology
Head & Neck
Head and Neck Pathology
Histology and Histopathology
Neuro-oncology
Neurosurgery
Virchows Archiv
International Journal of Surgical Pathology